Novel Controllable-Wettability Gradients on Polypropylene Surfaces for Cell Screening

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Statement of Purpose

The surface-property gradients permit multiple experimental parameters to be determined in parallel in a single analytical step, thus economizing the operational time and the quantity of required consumables. Because the hydrophilicity and hydrophobicity of a surface governs the attachment and growth of cells and bacteria, a wettability gradient which contains the opposite properties are particular advantageous.[1] In this study, a controllable method for creating wettability gradient on polypropylene membrane surface was created effectively by SF_6 plasma treatment under a mask application. The wettability of the treated surface ranged from strong hydrophilic (20° water contact angle) to nearly superhydrophobic (135°). The fabrication process is controllable to create gradients on samples from 1 cm to be 7 cm by controlling SF_6 plasma treatment time from 15 to 280 s. The resulted gradients provide a useful cell screening platform.

Methods

Polypropylene membrane (Celgard®) (Hoechst, NC, USA) was cleaned with ethanol and deionized water. The plasma system employed in this study was described elsewhere [2]. The gap between the mask and substrate was 1 mm. Oxygen-plasma pretreatment was performed at a flow rate of 10 sccm and 80 W of power for 600 s under 100 mTorr of total pressure. The SF_6 plasma treatment was conducted by applying gas at flow rate of 10 sccm for 15 s at 20 W and 100 mTorr of total pressure. The wettability of the surfaces was evaluated by measuring the static contact angles (Sindatek) with deionized water. The chemical compositions of the plasma-treated samples were determined by electron-spectroscopy for chemical analysis (ESCA) on a Thermo VG Scientific Theta Probe Instrument using Al (1,486.6 eV) and Mg (1,253.6 eV) as excitation sources.

Results and Discussion

The manufactured wettability gradient was characterized by contact angle measurements and the profile is shown in Figure 1. A wide range of wettability, from strong hydrophilic (20°) to nearly superhydrophobic (135°) wais successfully created on a sample of 1 cm, resulting in a gradient of 115° per centimeter. The ESCA wide-scan spectra (Figure 2) revealed a continuous evolution of all elements resulted from the plasma treatments. The created hydrophobic gradient was believed to be closely related to the fluorine content imbued by SF_6 plasma diffusion. The fluorine-to-carbon content ratio (F/C ratio) shown on inset of Figure 2 described that at the open end it had a value of 0.99, indicating that the fluorine dominated the surface, resulting in the hydrophobicity. As the fluorine content decreased sequentially, to 31 % at position 2, 17 % at position 3 and 3.5 % at position 4, the contact angles decreased correspondingly. From position 4 to the closed end of the sample, the fluorine content stayed at a constant value of 4-5 % due to limited incorporation of fluorine. Because the surfaces in contact with biomolecules were reported to play essential roles on governing the response of the cells and their adhesion to the surface of biomaterials, the created gradient provides potential applications in cell culture screening, lab-on-chip, and microarrays.[3]

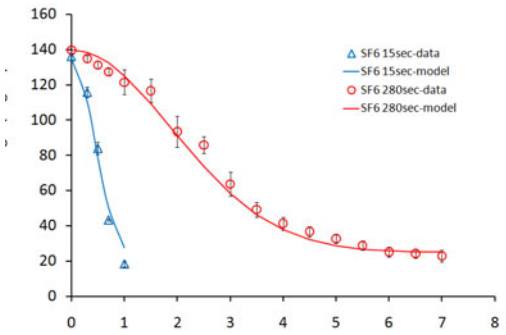

Figure 1. Water contact angle profile of the produced wettability gradients

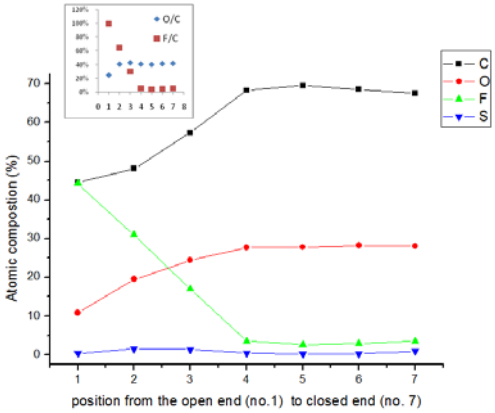

Figure 2. The evolution of atomic composition on the created gradient (1cm PP treated by SF_6 plasma; Inset: O/C and F/C ratio)

Conclusions

A novel controllable wettability gradient with strong hydrophilic and nearly superhydrophobic ends was successfully fabricated and was scaled-up to 7 cm sample. Fluorine binding on the surface is responsible to its hydrophobicity. This gradient would be a powerful tool to investigate wettability effect on cell screening.

References

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[3] Chen G., Imanishi Y, and Ito Y, J Biomd Mats Res Part A, 1998. 42(1): 38 - 44.